CERES TRMM-PFM-VIRS SSF Edition1 Surface Fluxes - Accuracy and Validation

One of the objectives of the CERES data products is to provide improved estimates of surface fluxes (net and downward) for shortwave (SW) and longwave (LW) radiation. The main effort is to obtain consistent surface, within atmosphere, and top of atmosphere fluxes and will be produced in the CERES CRS data product, using the Edition2 SSF as input data. But initial CRS surface fluxes will not be available until Spring 2002. A second effort attempts to use much simpler algorithms to either:

- directly tie surface fluxes to broadband CERES TOA fluxes such as in Li et al., 1993 and Staylor and Wilbur, 1990 for SW fluxes, and Inamdar and Ramanathan (1997) for clear-sky LW surface fluxes.
- use simple radiative parameterizations (Gupta, 1989 and Gupta, Darnell, and Wilber, 1992) to estimate surface fluxes: especially for surface downward LW fluxes which can have little relation to TOA fluxes in cloudy sky conditions.

Therefore, these simpler parameterization SSF surface fluxes are more comparable to results used in past analyses of surface radiation data sets based on ERBE or geostationary data. In general they are not expected to be as accurate as the CERES CRS surface fluxes, but represent an independent method to get to the more difficult surface flux estimates.

The CERES SSF data product provides 4 surface flux algorithm results:

1. Shortwave Flux Model A Clear-sky only: Net surface flux uses Li et al., 1993; Downward surface flux uses Li et al., 1993 for net and Li and Garand, 1994 for surface albedo
2. Shortwave Flux Model B Clear-sky only: Net surface flux uses Li et al., 1993; Downward surface flux uses Staylor and Wilber, 1990 for net and surface albedo
   (Note: There is an inconsistency in the Model B net and downward surface fluxes.)
3. Longwave Flux Model A Clear-sky only: uses Inamdar and Ramanathan, 1994
4. Longwave Flux Model B Cloudy and Clear-sky: uses Gupta, 1989 and Gupta, Darnell, and Wilber, 1992.

In Edition1 only limited surface fluxes are available as shown below. Edition2 will have new angular models for TOA all-sky fluxes which will enable surface shortwave all-sky results for Model B shortwave. In Edition1, clear-sky is defined as a CERES footprint with an imager determined cloud cover percentage less than 0.1%.

Available Surface Fluxes

	Clear-sky	**All-Sky**
SW Model A	Edition1, Edition2	-
SW Model B	Edition2	Edition2
LW Model A	Edition1, Edition2	-
LW Model B	Edition1, Edition2	Edition1, Edition2

The SSF surface fluxes have been validated using both theoretical analyses and simultaneous matching of TRMM satellite and a range of surface sites.

The CERES SSF surface flux estimates were obtained using Tropical Rainfall Measuring Mission (TRMM) satellite data for January through August of 1998. The coincident surface fluxes were then gathered from the 21 sites of the Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) network, the 6 sites of the Climate Modeling and Diagnostic Laboratory (CMDL) network, and the 4 sites of the Baseline Surface Radiation Network (BSRN). Surface site fluxes are averaged for 30 minutes and are compared to the CERES footprint nearest the surface site. TRMM overpass time must fall within the 30 minute period.

Clear-sky Shortwave Downward Flux Validation: Model A and B

For the shortwave, two models have been used to produce the surface fluxes. Both of these shortwave models are part of our validation effort. Early results clearly demonstrated that the current shortwave models are unsatisfactory for cloudy sky conditions. Thus, we have concentrated on clear-sky conditions until either suitable modifications can be made to the current models or alternative models can be formulated.

As can be seen in the following table, for clear sky conditions the shortwave models are found to be in reasonably good agreement with the surface measurements at the ARM/CART SGP sites. At the CMDL and BSRN sites, however, factors of 2 to 3 larger exist between the surface fluxes derived from satellite data and the measured surface fluxes. These discrepancies are under investigation. Because the differences between models A and B are much smaller than the differences between derived and measured downward fluxes, the combined results are presented in the table.

Downward Shortwave Flux Comparisons, Clear-Sky

Site	# of Points	Mean Bias	RMS Difference
ARM Central Facility	156	17.4 W m^{-2}	50.0 W m^{-2}
ARM Extended Facilities	2225	24.0 W m^{-2}	60.7 W m^{-2}

All-sky Longwave Downward Flux Validation: Model B

Longwave model B uses the meteorological profiles and CERES VIRS-derived cloud properties, but not the CERES-measured TOA fluxes, to obtain surface fluxes for clear and cloudy sky conditions. As demonstrated by the following table, the results from longwave model B are found to be in good agreement with the surface measurements at all the sites.

Downward Longwave Model B Comparisons, All-Sky

Site	# of Points	Mean Bias	RMS Difference
ARM Central Facility	326	-1.3 W m^{-2}	26.3 W m^{-2}
Arm Extended Facilities	4572	-4.3 W m^{-2}	25.1 W m^{-2}
CMDL Facilities	586	1.3 W m^{-2}	20.5 W m^{-2}
BSRN Facilities	590	1.5 W m^{-2}	26.6 W m^{-2}

Clear-sky Longwave Downward Flux Validation: Model A

In theoretical error analysis, the standard errors of estimate for the surface LW model A clear-sky fluxes (see Inamdar & Ramanathan, 1997) are:

Open Ocean (Tropics: 30 N - 30 S)	4.4 m^{-2}
Open Ocean (Extra-tropics: 30 degree to pole)	3.2 W m^{-2}
Land	6.2 W m^{-2}

Validation studies employing data from Central Equatorial Experiment (CEPEX), reported in the study cited above, reveal good agreement consistent with the above error estimates. The parameterization over the land surfaces have been developed using limited set of emissivity data available from IRIS measurements aboard NIMBUS 4 (Prabhakara & Dalu, 1976). Other possible sources of errors are:

1. Specification of the true radiating temperature (especially land surfaces);
2. Errors in scene identification;
3. Emissions from aerosols in the boundary layer. For example, sensitivity studies have shown that thick haze in the boundary layer (visibilities less than 15 km) can increase the downward emissions by about 3 - 5 W m^{-2}.

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